# Human Expertise as the Critical Challenge in Participative Multidisciplinary Design Optimization

Evelina Dineva, Arne Bachmann, Uwe Knodt, and Björn Nagel

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DLR

# The Team

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Uwe Knodt


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DLR

# Founding and Projects

iTALENT

FrEACo

ILT
Institut für
Lufttransportsysteme

INTEGRATED
DESIGNLAB

ELWIS

TUHH
Technische Universität Hamburg-Harburg

DLR

# Overview

- context: DLR / ILT / IDL
  - issues with collaborative aircraft design
- experimental research
- the IDL in practice
- lessons learned

# Institute for Air Transportation Systems

ILT

Institut für
Lufttransportsysteme

Future Air Transportation —
Which technologies do we need?

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# Institute for Air Transportation Systems

ILT

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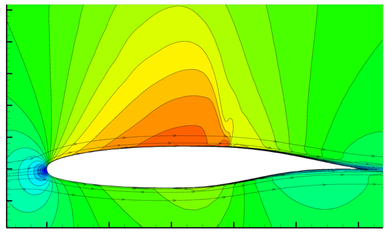

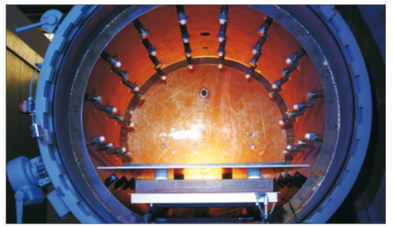

Propulsion

Dynamics

Structure

Technologies

Future Air Transportation —
Which technologies do we need?

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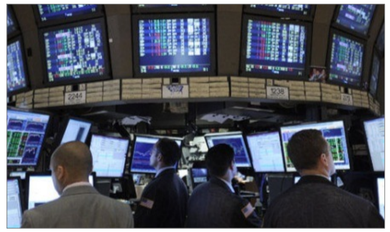
# Institute for Air Transportation Systems

Demands

Mobility

Environment

Economy



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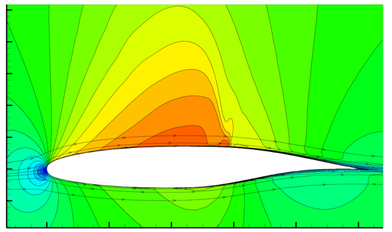
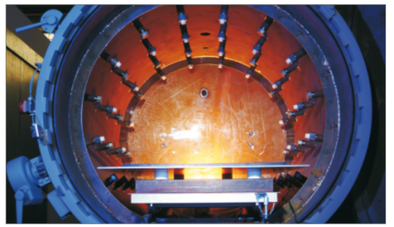
Technologies

Propulsion

Dynamics



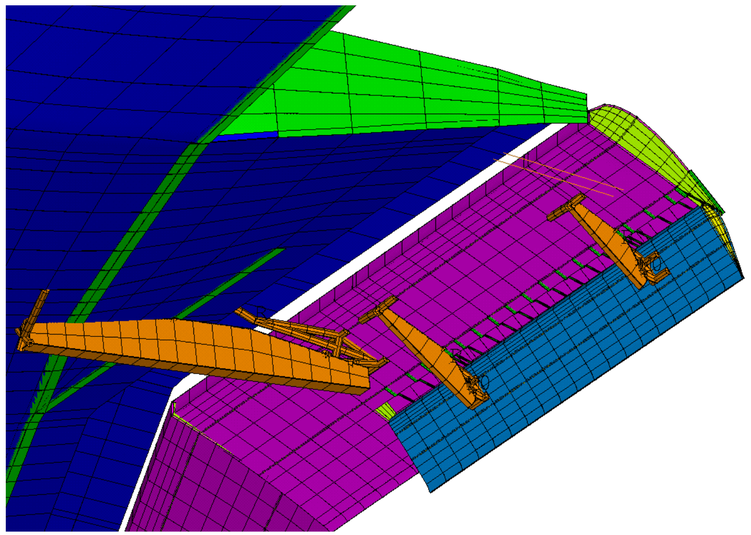
Structure



Future Air Transportation —
Which technologies do we need?

DLR

# Bridging Visions and Practical Solutions



models with appropriate precision

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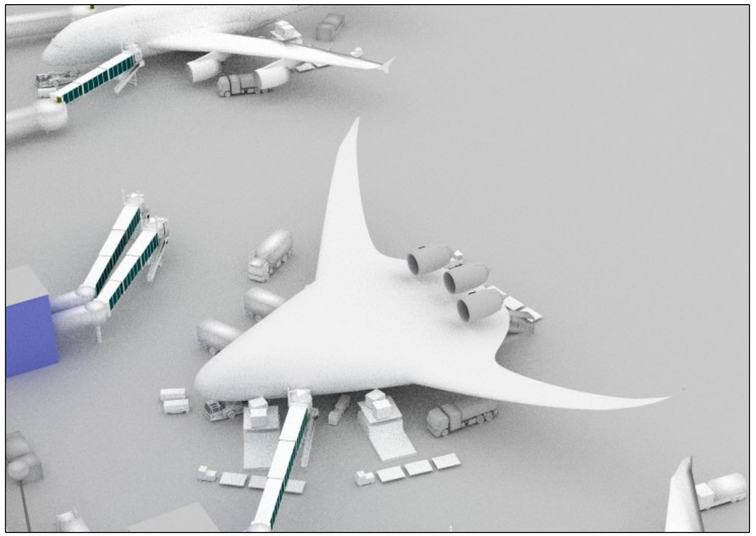
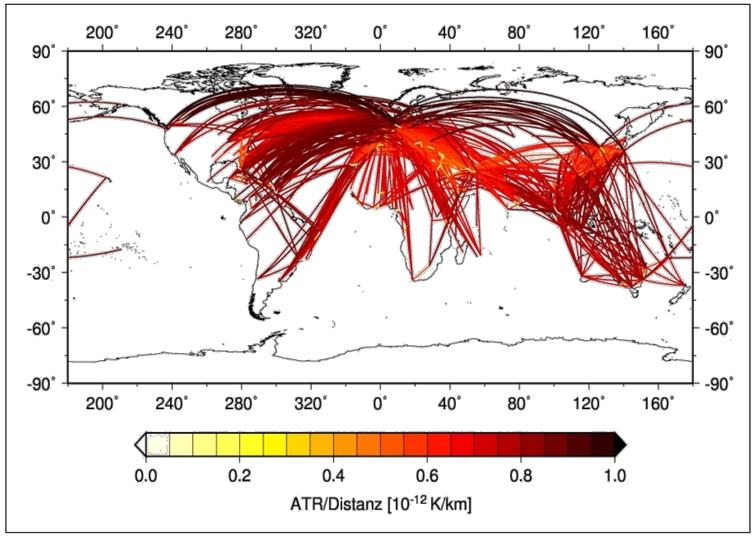
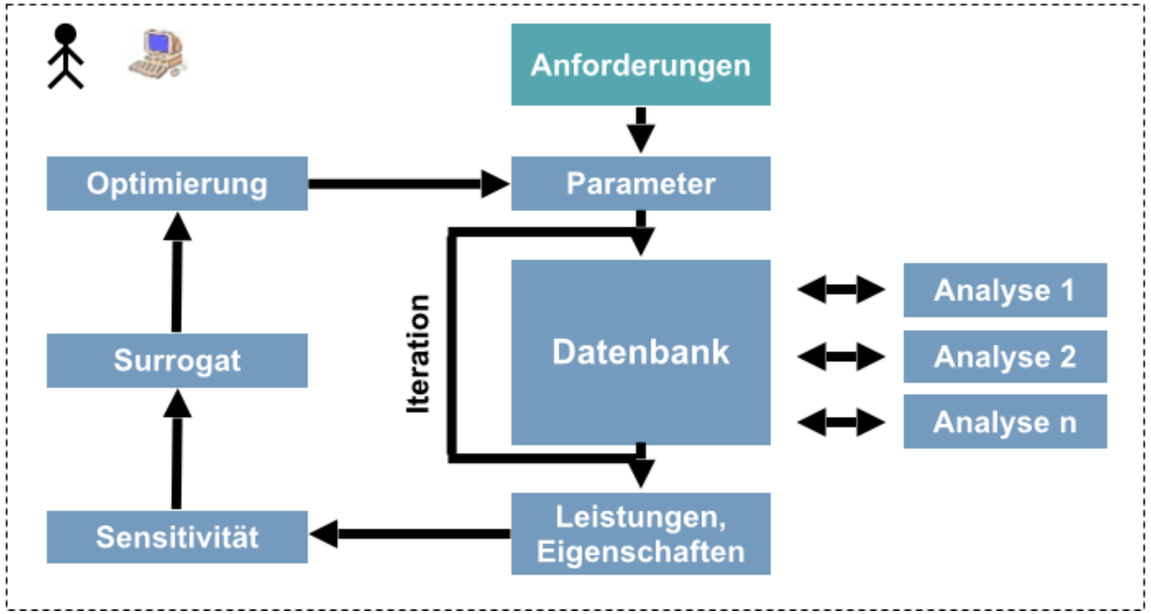


considering any relevant effects

taking the entire system into account




# Participative MDO

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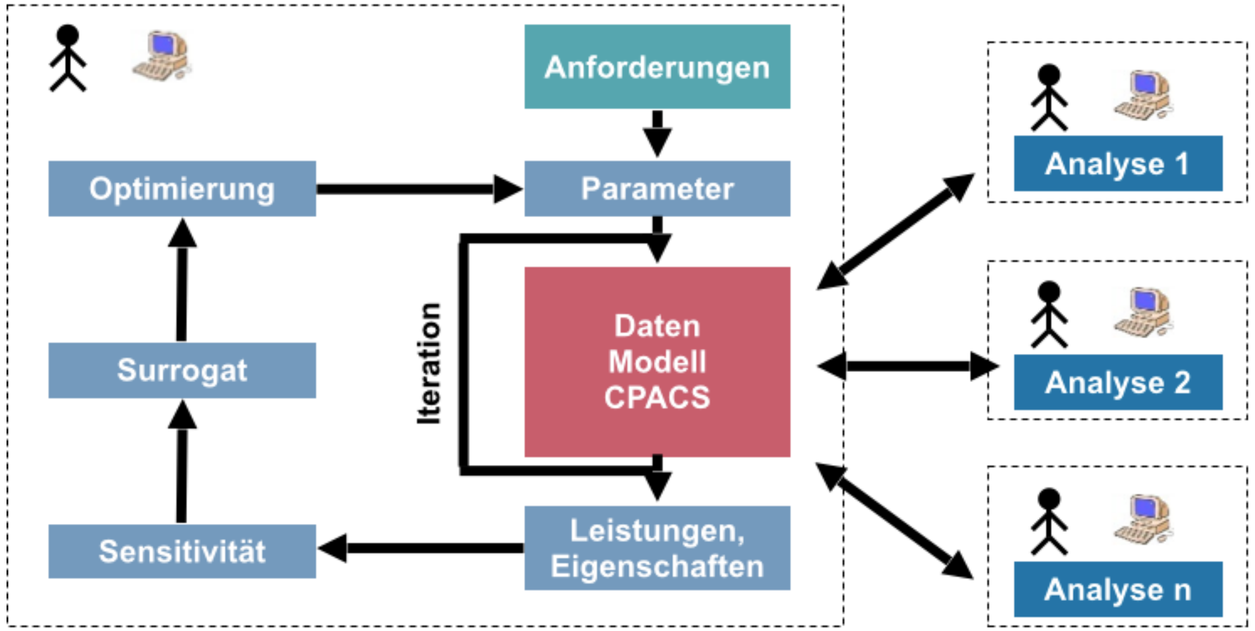


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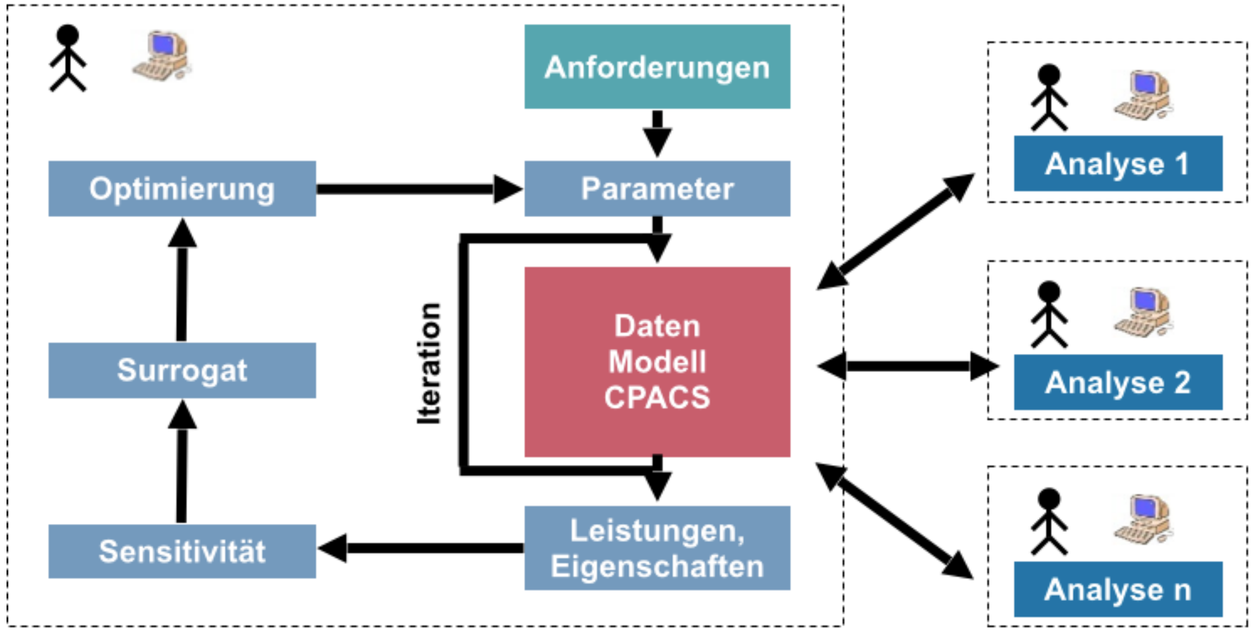


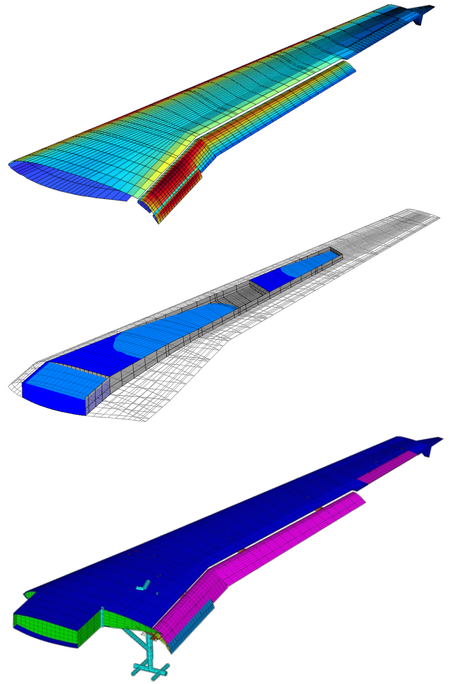

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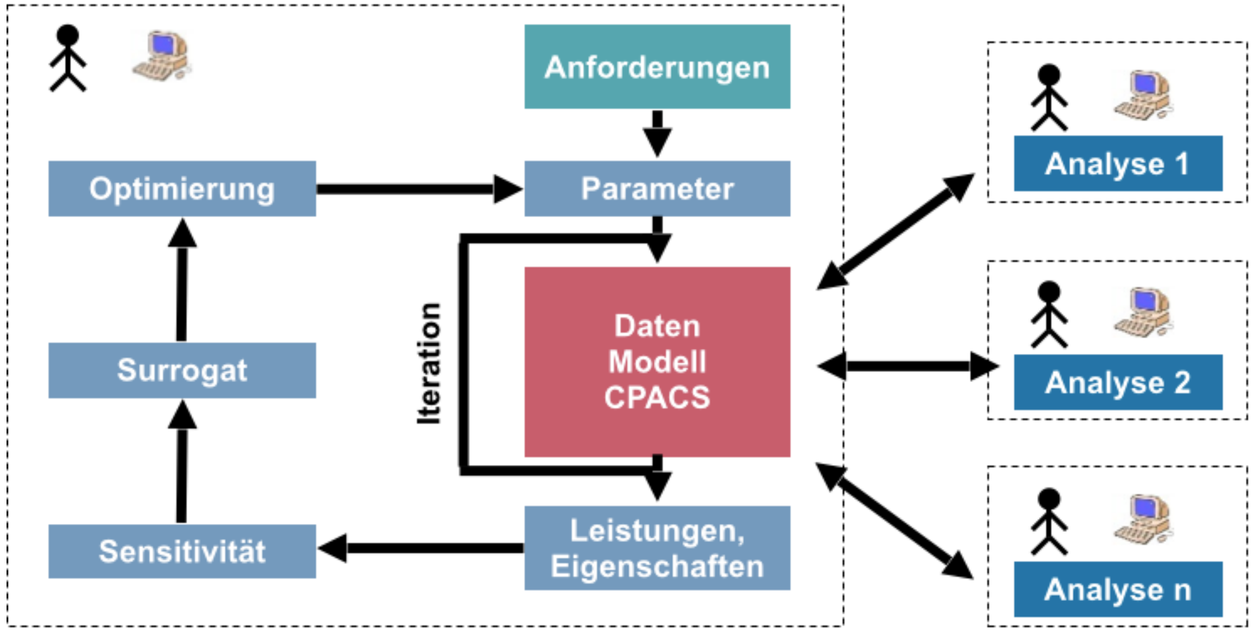
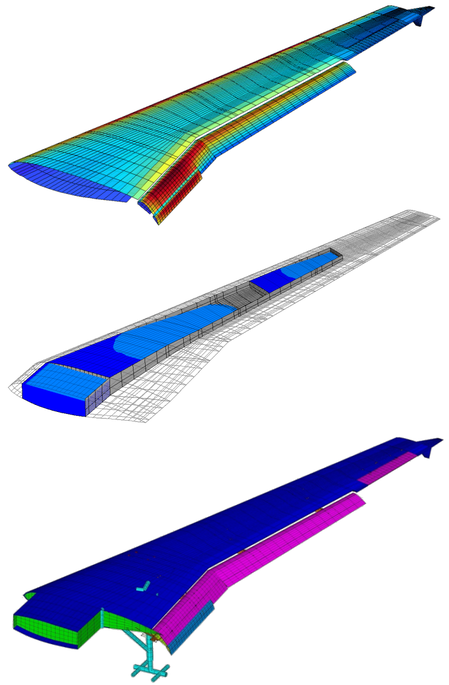
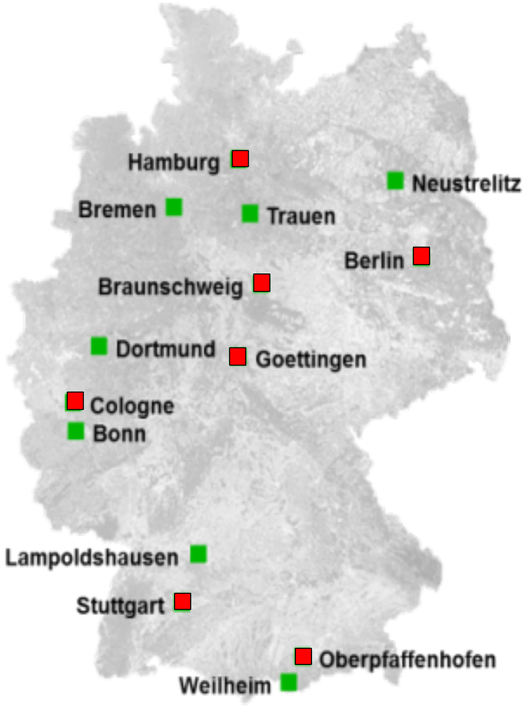


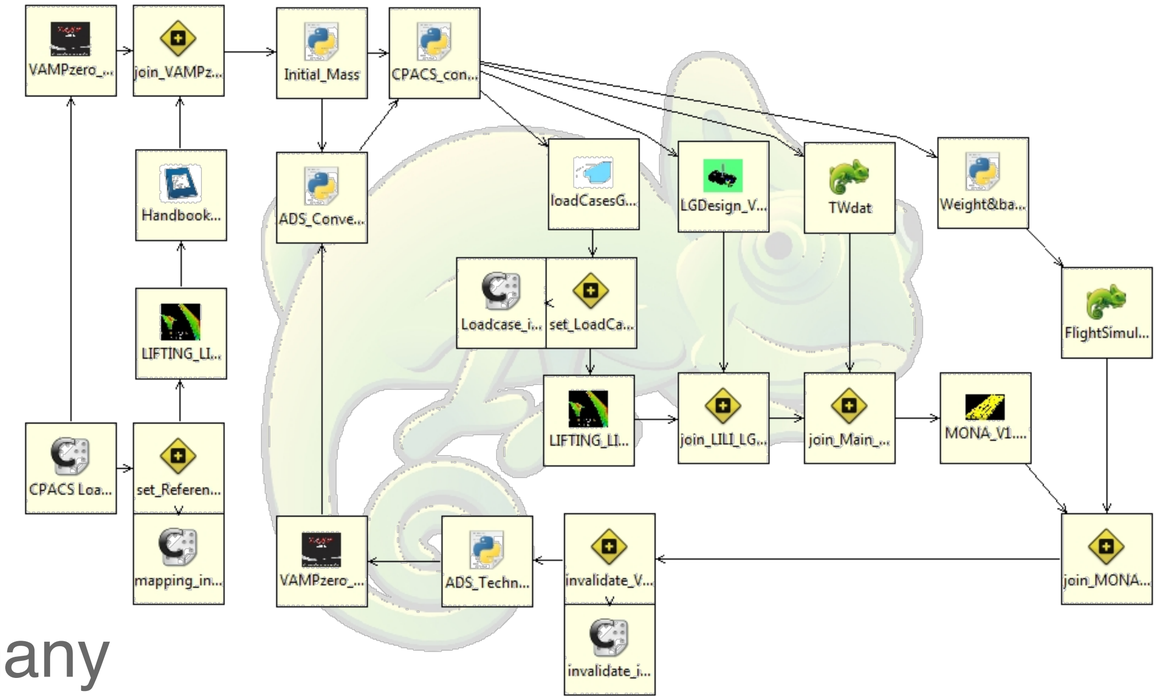
Challenge: Harnessing the (distributed) skills

# VAMPzero Project




DLR locations in Germany
[red] involved in VAMPzero

analysis chain of multiple institutes involved in the VAMPzero Project




tools don't provide skills

# Experimental Research

# Experimental Set Up

# On the Computer

- control panel: sliders, buttons, text edit …
- input display: selected parameters over all trials
- ouput display: resulting parameters over all trials

GUI

- CPACS: xml-type file with aircraft data
- VAMPzero: preliminary aircraft design tool

Software

- demographic
- mouse trajectories
- inputs (GUI actions)
- calculated results
- questionare

Data

# The Aircraft Design Task

- 3 control parameters: values that the participants may change
- 2 output parameters: obtained results, that the participants need to optimize

| type | control parameters | | | output parameters | |
|---|---|---|---|---|---|
| **name** | design range | wing span | bypass ratio | DOC | OEM |
| **range** | 350 - 7000 | 14 - 44 | 3.5 - 7 | 4000 - 12000 | 3 - 130 |
| **step-size** | eight discrete | continuous | continuous | n/a | n/a |
| **unit** | [km] | [m] | [-] | [EUR/h] | [t] |

# Experimental Design (Simplified)

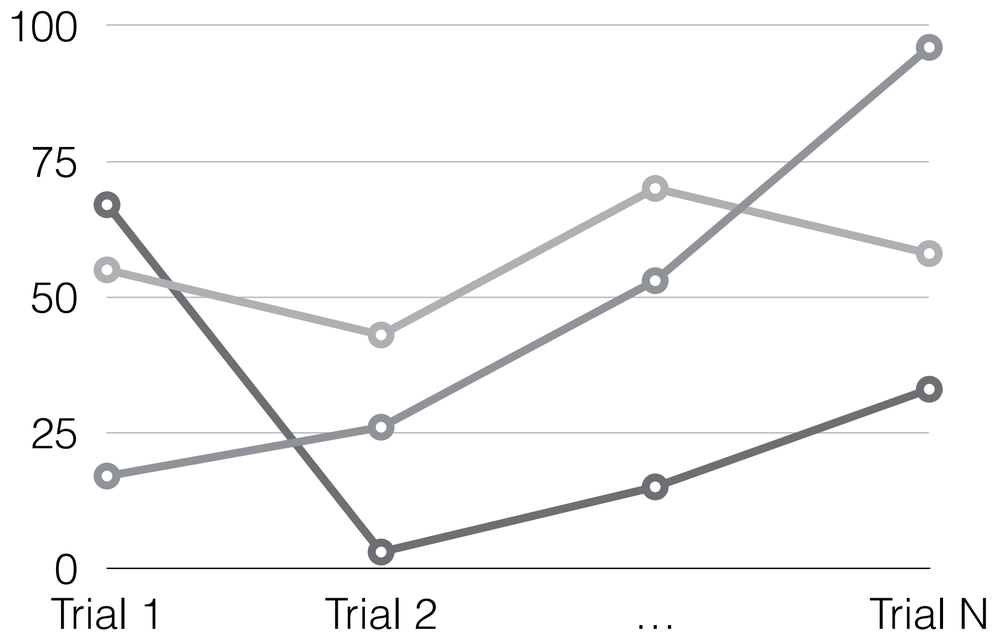
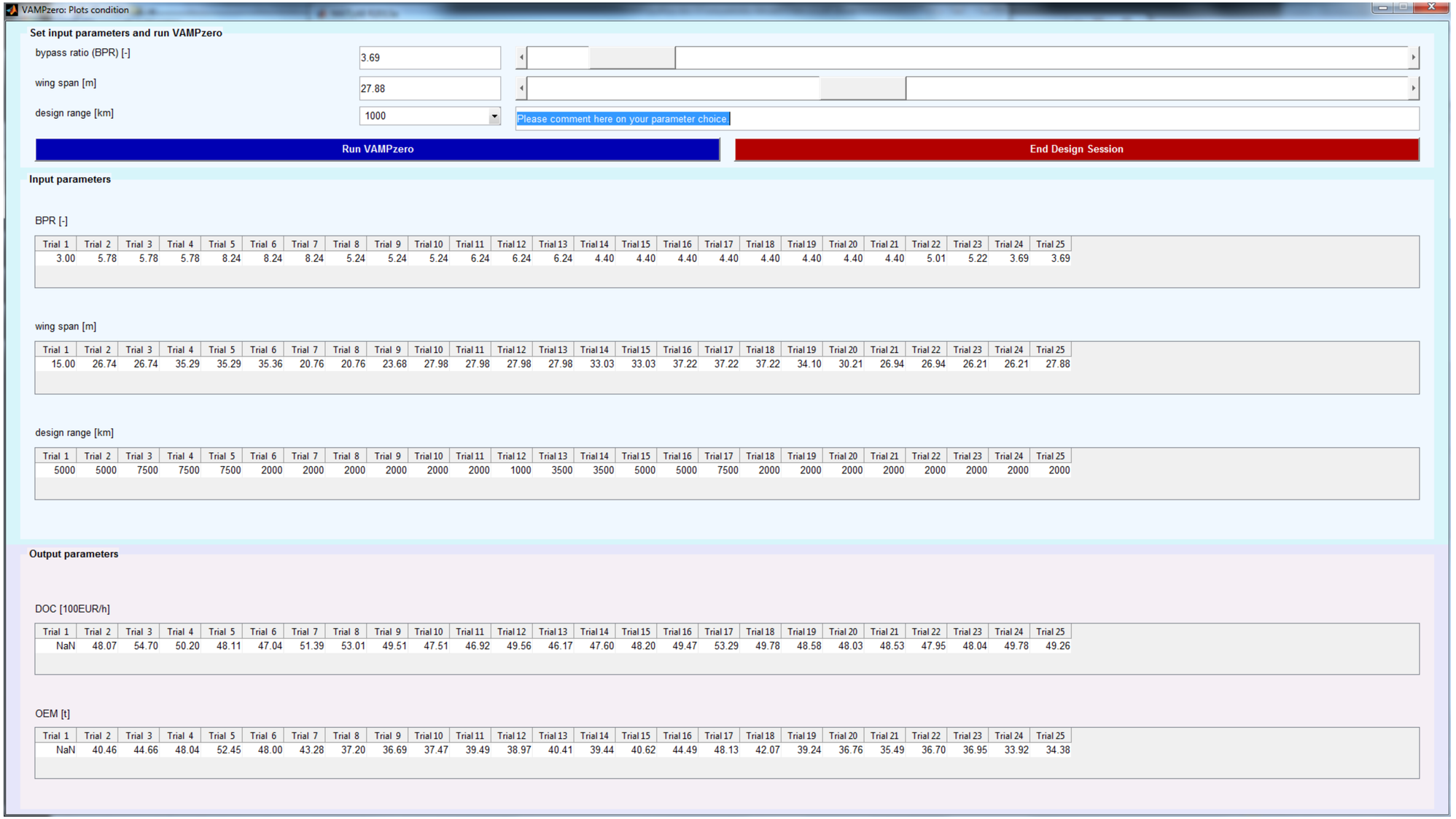



Figure Condition

| | Trial 1 | Trial 2 | … | Trial 4 |
|---|---|---|---|---|
| **P1** | 17 | 26 | 53 | 96 |
| **P2** | 55 | 43 | 70 | 58 |
| **P3** | 67 | 3 | 15 | 33 |

Table Condition


# Figure Condition




# Table Condition

# Participants

- seven participants per condition (total: 14)
- all were novice engineering students w/o significant experience in aircraft design

# Simplified Analysis

Manipulated by experimental design — each participant is in either of these conditions:

- Figure
- Table

Control Variables

Measured in the experiment for each participant:

- min-DOC
- min-OEM
- min-COMB (OEM+10DOC)
- Duration
- Trials

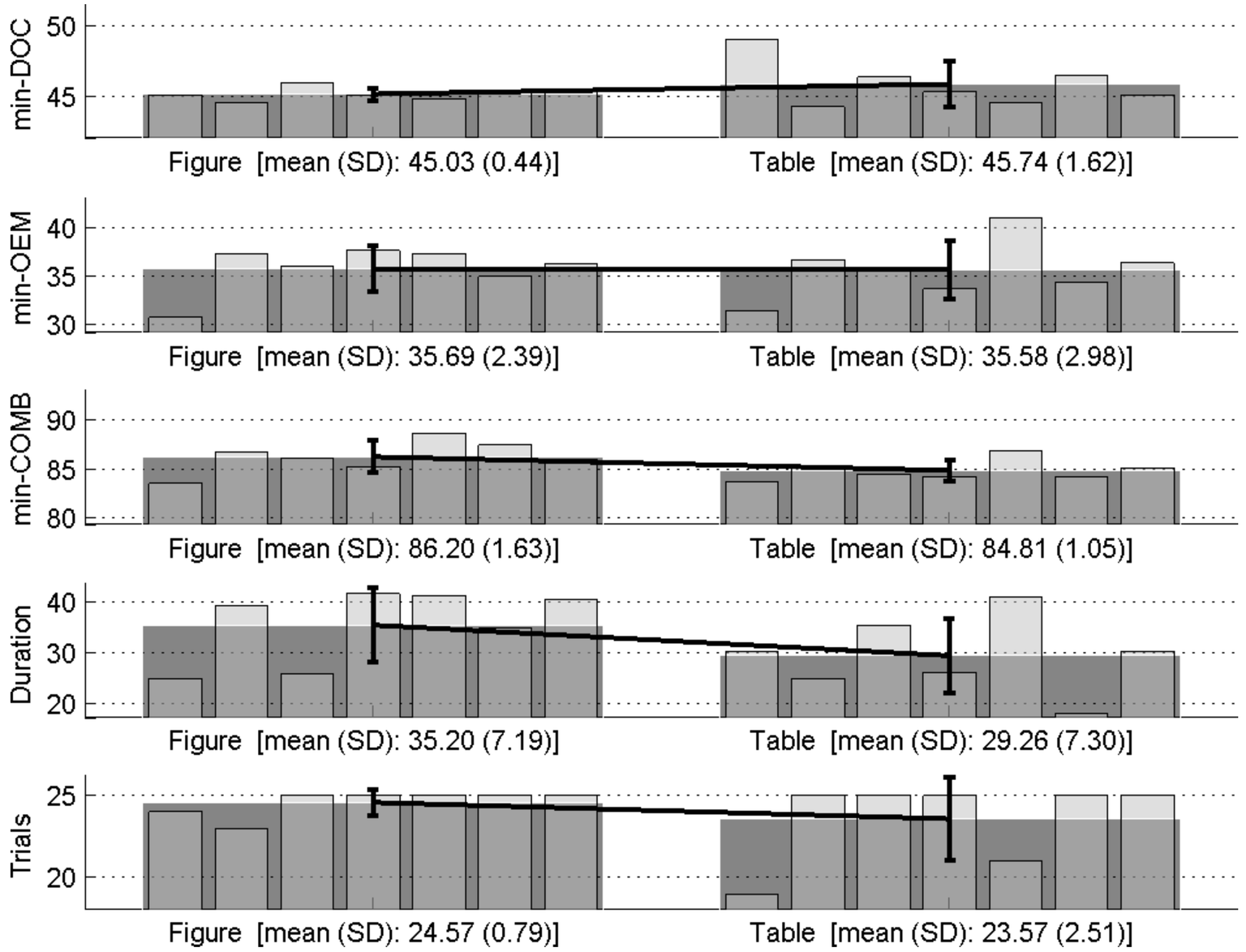
Dependent Variables

# Dependent Variables / Measurements

- **min-DOC** the minimal DOC value, that a participant has achieved;
- **min-OEM** the minimal OEM value, that a participant has achieved;
- **min-COMB** the combined minimum of (OEM+10DOC), which a participant has achieved among all their values (the factor 10 was selected to offset the different orders of magnetite in VAMPzero calculates the two parameters);
- **Duration** the time a participant needed to finish the design session (out of maximal 40 minutes);
- **Trials** the number of trials a participant needed to finish the design session (out of maximal 25 trials).

# Results

- no significant effects
- tendency to be faster in the Table condition
- problem: possible trial and error approach

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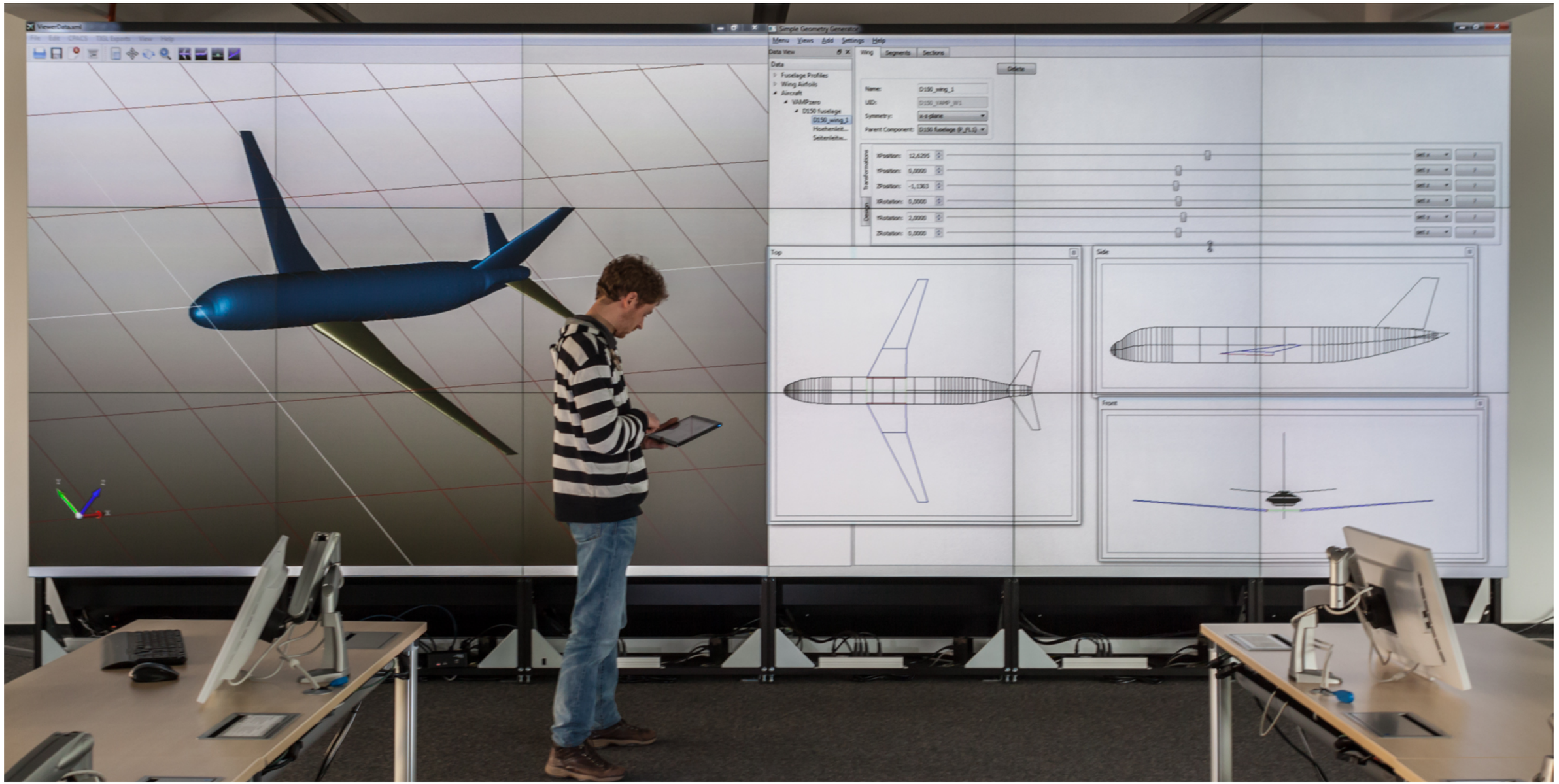
Simple Geometry Generator
Menu Views Add Settings Help
Data View
Data
Fuselage Profiles
Wing Airfoils
Aircraft
VAMPzero
D150 fuselage
Wing
Segments
Sections
Delete
Name:
UID:
Symmetry:
Parent Component:
Top
Side
Front

# Setting Scenarios


# Setting Scenarios

# Lessons Learned

## Improved Lessons Learned Process